IFSTTAR

High Performance?

Impact of Equivalent Young's Modulus Ratio Values b/w Material Layers on Pavement Structural Fracture Performance

Armelle Chabot

Materials & Structures Department

https://www.lames.ifsttar.fr/

RILEM High Performance Asphalt Materials Symposium

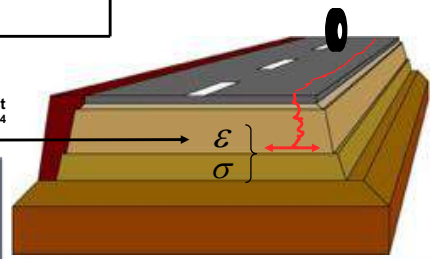
University of Waterloo, Oct. 2nd, 2019

French Context

(SETRA-LCPC, 1994)

$$\varepsilon_{t,adm} \leq \varepsilon_6 \times \left(\frac{NE}{10^6}\right)^b \times kc \times kr \times ks \times kd$$

*Fatigue test
NF EN 12697 - 24



(Burmister, 1943)
- Elastic Multilayers
- 2D axisym.
- Half ∞ space

E*eq (15°C, 10Hz); ν=0.35

Corte JF, Goux MT (1996) Design of pavement structures: the French technical guide. *Transp Res Rep* 1539:116–124

Stiffness of French pavement materials

Modulus range in MPa

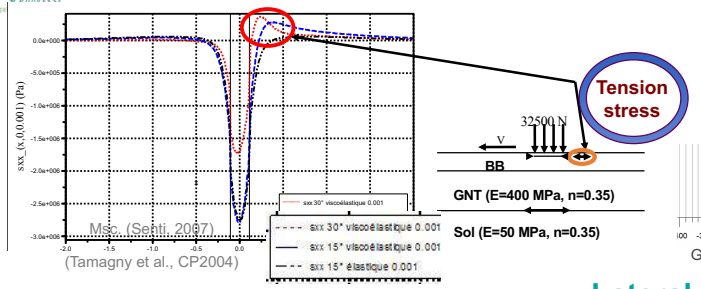
- Subgrades — 20-200
- Unbound materials — 200-600
  - Unbound granular materials
- Bituminous materials — 3000
  - Gravel emulsion
  - Bituminous concrete (BB) — 5000
  - Grave Bitume (GB) — 9000
  - **High modulus bit. mix (EME)** — **14000**

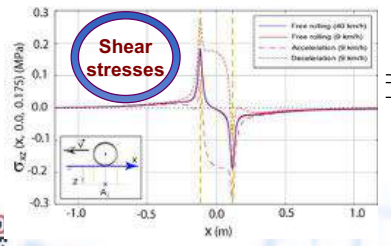
15°C 10Hz

- Hydraulic materials (GC)
  - Gravels and Sands treated with HB — 15-30000
  - Concrete — 24-35000

360 days

… But for top layers ?





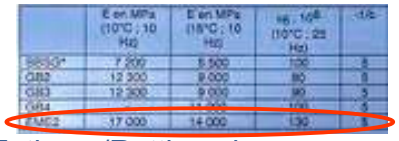
Lateral loadings

DEVIN PROJECT
INRETS - LMT Cachan - SMIT/LCPC
(Hammoum et al., 2010)

Hammoum F., Chabot A., St. Laurent D., Chollet H., Vulturescu B. (2010). Accelerating and Decelerating Effects of Tramway Loads moving on Bituminous Pavement. *Materials and Structures*, 43:1257-1269

ViscoRoute©(LCPC,2009) simulations

EME2 uses & limitations?

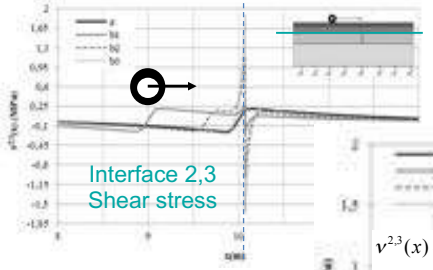


- Good performance:
  - ✓ High Young modulus → Fatigue /Rutting ok
  - ✓ Used for heavy traffic or bus way
- **But need**

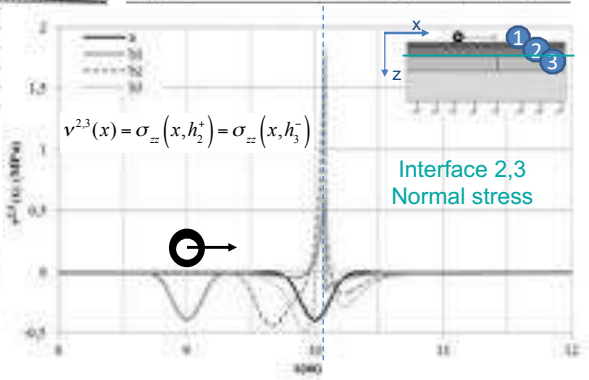
  - ✓ Good soil
  - ✓ Thickness design value
    - Correct traffic hypothesis
  - ✓ Construction care: Cst % of void and **good bond** between layers

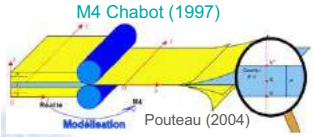
Dedicated pavement analysis

Tran PHD thesis (2004) & Nasser PHD thesis (2016)



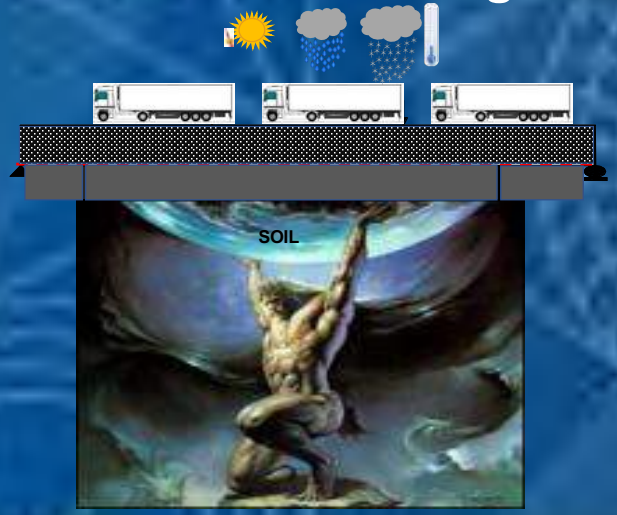
Material	Thickness (m)	Young's modulus (MPa)	Poisson's ratio
BBSG	e^1=0.08	E^1=5400	υ^1=0.35
GB3	e^2=0.15	E^2=9300	υ^2=0.35
GC3	e^3=0.23	E^3=23000	υ^3=0.25
Soil	-	E^4=120	υ^4=0.35





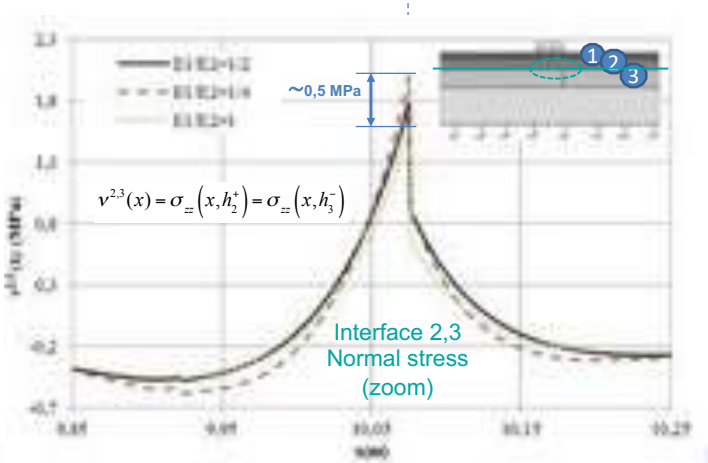
Chabot, A., Tran Q. D., Ehrlacher A., 2007. A modeling to understand where a vertical crack can propagate in pavements. In Proc. *Advanced Characterization of Pavement and Soil Engineering Materials*, 1: 431-440.
Nasser H., Chabot A., 2018. A Half-analytical Elastic Solution for 2D Analysis of Cracked Pavements. *Advances in Engineering Software*, 117: 107-122.

Bending case with Discontinuities and climate change

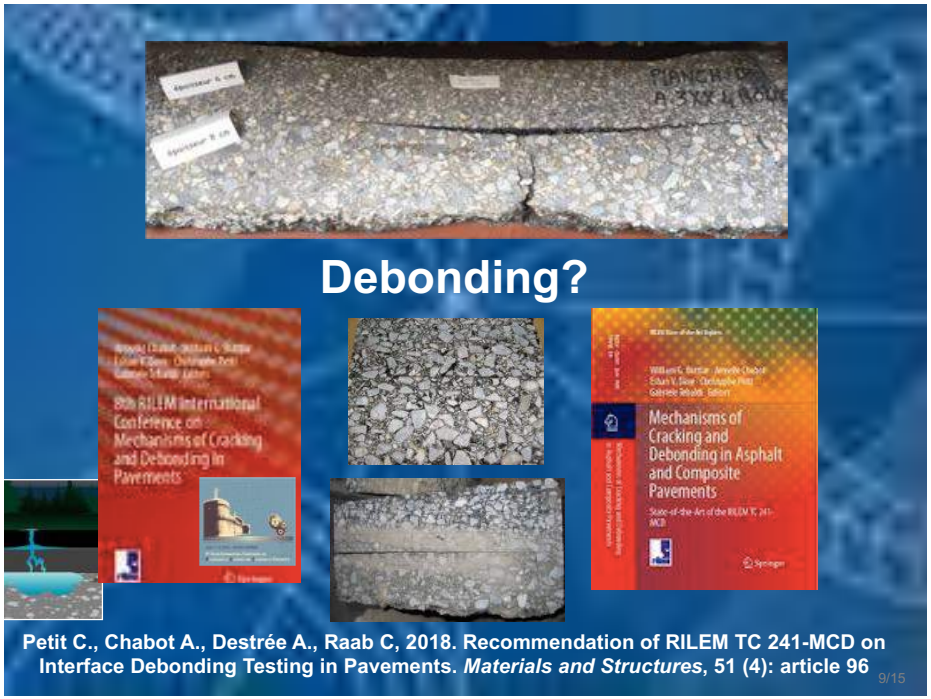


Dedicated M4-5nW analysis

≠T°C → Effect of ≠ E Ratio on Interface stresses



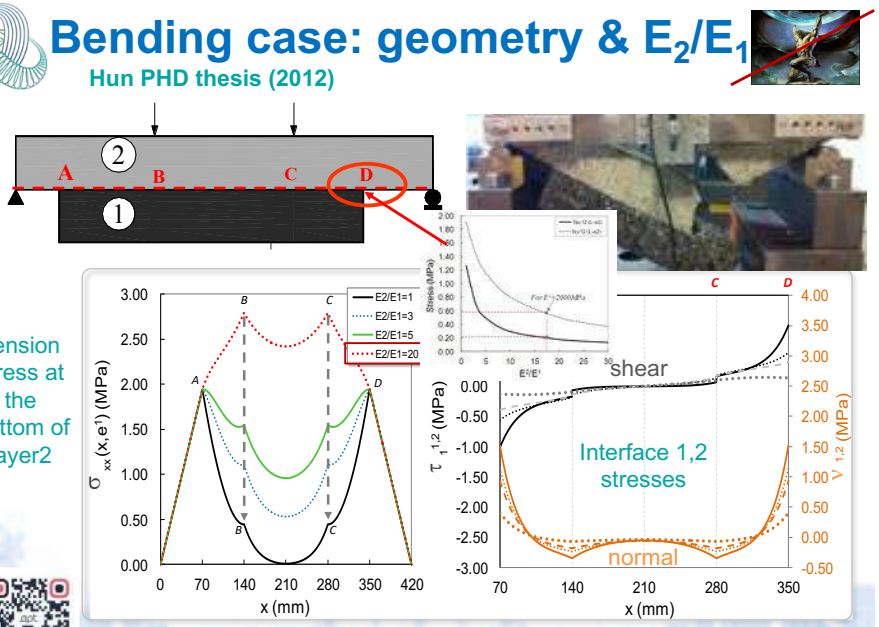
Nasser H., Chabot A., 2018. A Half-analytical Elastic Solution for 2D Analysis of Cracked Pavements. *Advances in Engineering Software*, **117**: 107-122.



Petit C., Chabot A., Destrée A., Raab C, 2018. Recommendation of RILEM TC 241-MCD on Interface Debonding Testing in Pavements. *Materials and Structures*, 51 (4): article 96

Bending case: geometry & E_2/E_1

Hun PHD thesis (2012)

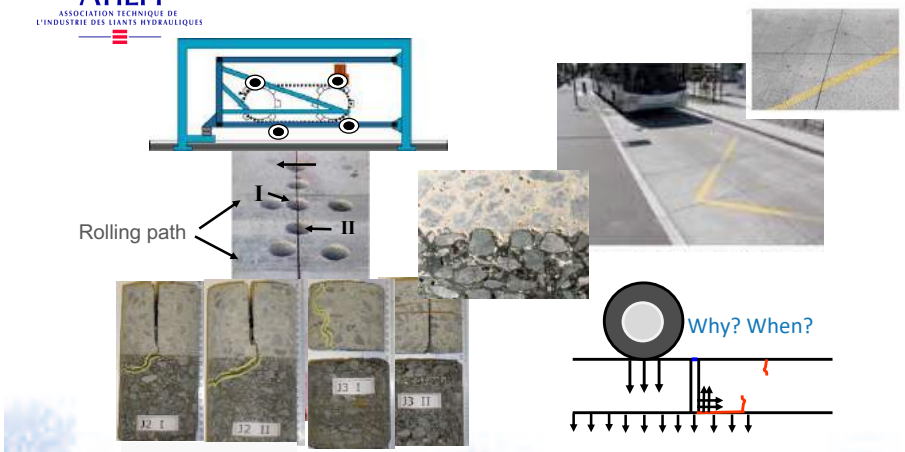


Chabot A., Hun M., Hammoum F., 2013, Mechanical analysis of a bond test between layers of composite pavements, *CBM*, 40:1076-1088

Bond ALT for urbain French roads

Pouteau PHD thesis (2004)

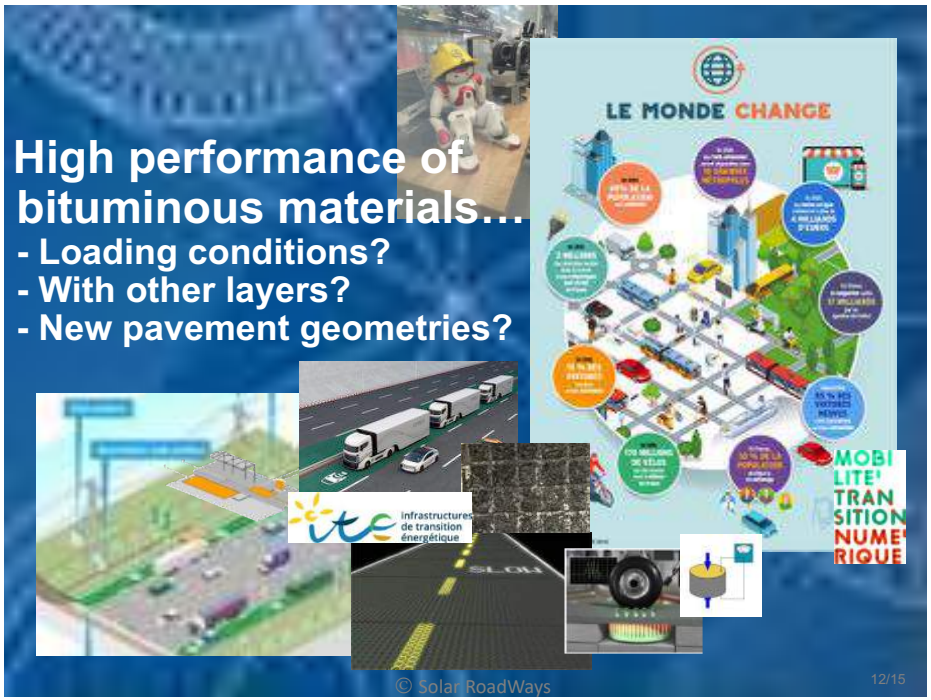
ATILH
ASSOCIATION TECHNIQUE DE L'INDUSTRIE DES LIANTS HYDRAULIQUES



Chabot A., Pouteau B., Balay J.-M., De Larrard F., 2008. FABAC Accelerated Loading Test of Bond between Cement Overlay and Asphalt layers. *RILEM CP2008*, June 16-18, Chicago, US.

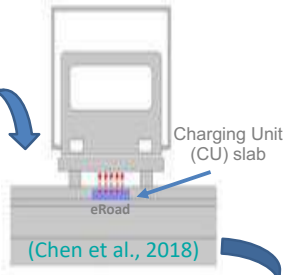
High performance of bituminous materials…

- Loading conditions?
- With other layers?
- New pavement geometries?

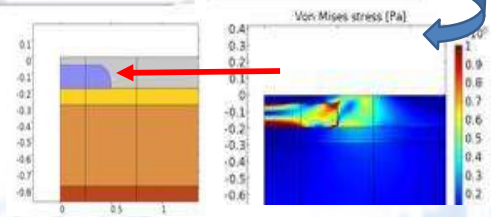


© Solar RoadWays

eRoads examples



(Chen et al., 2018)

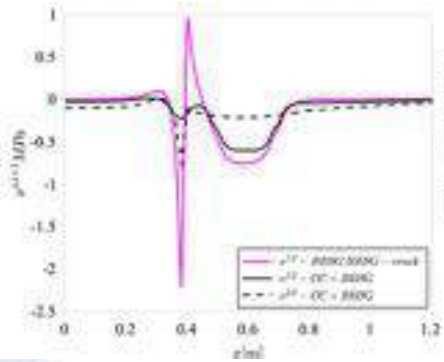


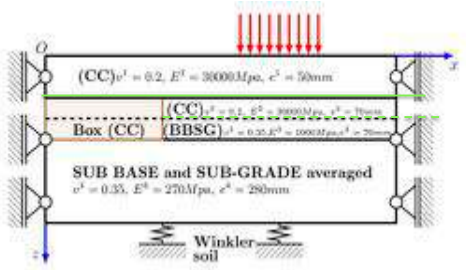
One Geometrical Solution proposed
by KTH (Chen, PHD 2016)

Chen, F., Balieu, R., Cordoba, E., & Kringos, N. (2018). Towards an understanding of the structural performance of future electrified roads: A finite element simulation study. *IJPE*, 20 (2): 204-215.

https://apt2020.sciencesconf.org/ → Registration open!

eRoad composite system
(Chabot & Deep, 2019)

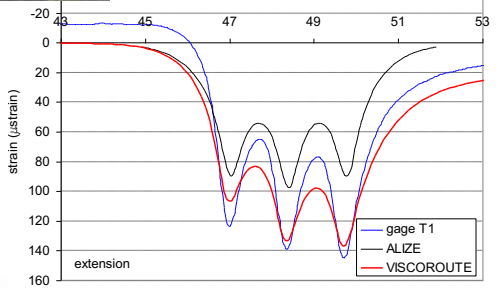




High Bond Performance Needs!

Chabot A., Deep P., 2019. 2D Multilayer Solution for an Electrified Road with a built-in Charging Box. *RMPD*, 20 (sup2), s590-s603.

Multi-axle loads
ALT vs visco-elastic calculus
(Kerzreho et al., 2012)



Kerzrého J.P., Hornych P., Chabot A., Deloffre L., Trichet S., Coirier G., Gouy T, 2012. Evaluation of the aggressiveness of different multi-axle loads using APT tests. *In Advances in Pavement Design through Full-scale Accelerated Pavement Testing*. Jones, D., Harvey, J., Al-Qadi, I. and Mateos, A. (Eds): 505–517.